Vol. 1 (2008) *Acta Physica Polonica B Proceedings Supplement* No 3

PARTICLE PRODUCTION IN DIS AND PHOTOPRODUCTION FROM *ep* COLLISIONS*

Anna Galas

on behalf of H1 and ZEUS Collaborations

The H. Niewodniczański Institute of Nuclear Physics, Polish Academy of Sciences
Radzikowskiego 152, 31-342 Kraków, Poland
galas@ifj.edu.pl

(Received October 16, 2008)

A review of recent particle production and fragmentation results from H1 and ZEUS are presented for deep inelastic scattering (DIS) and photoproduction (γp) at HERA on a wide range of topics.

PACS numbers: 13.60.Le, 13.85.–t, 13.90.+i, 27.10.+h

1. Introduction

This article reports recent results from H1 and ZEUS experiment on:

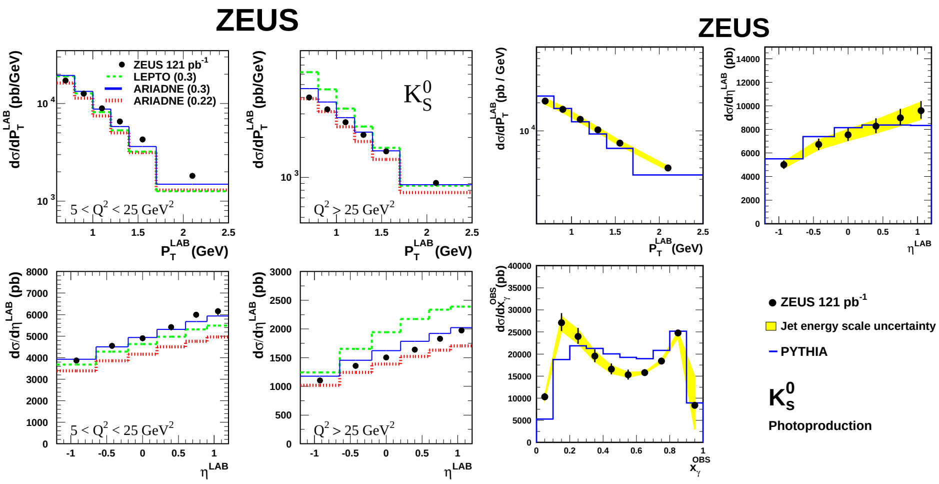
- Measurement of $K^0_{\rm S}$, Λ and $\bar{\Lambda}$ production in DIS and γp [1].
- Bose–Einstein correlations (BEC) of $K^0_{\rm S}K^0_{\rm S}$ and $K^{\pm}K^{\pm}$ in DIS [2].
- Studies of (anti)deuteron and (anti)proton production in DIS [3] Measurement of scaled momentum spectra in high Q^2 in DIS [4, 5].

2. $K^0_{\rm S}$, Λ and $\bar{\Lambda}$ production in DIS and γp

The production of strange hadrons $K^0_{\rm S}$, Λ and $\bar{\Lambda}$ has been studied in three different regions of virtuality of the exchanged bosons, Q^2: in DIS at $Q^2 > 25$ GeV^2, in DIS at 5 GeV$^2 < Q^2 < 25$ GeV^2 and in γp at $Q^2 < 1$ GeV^2, where the two jets, each of at least 5 GeV in transverse energy, were required. The following measurements have been performed: differential cross-sections, baryon–antibaryon asymmetry $\frac{N(\Lambda)-N(\bar{\Lambda})}{N(\Lambda)+N(\bar{\Lambda})}$, baryon to meson ratios $\frac{N(\Lambda)+N(\bar{\Lambda})}{N(K^0_{\rm S})}$ and strange to light hadrons ratios $\frac{N(K^0_{\rm S})}{N(\text{charged particles})}$.

* Presented at the XXXVII International Symposium on Multiparticle Dynamics, Berkeley, USA, August 4–9, 2007.

The results were obtained as a functions of transverse momentum, $p_T^{K_S^0,\Lambda,\bar{\Lambda}}$, pseudorapidity, $\eta^{K_S^0,\Lambda,\bar{\Lambda}}$, the Bjorken variable, x_{BJ}, and Q^2 for both, low and high Q^2 DIS samples, and as a functions of p_T^{LAB}, η^{LAB} and the fraction of the photon energy transfered to dijet system, x_γ^{OBS}, for γp. The differential K_S^0 cross-sections for DIS and γp are shown in Fig. 1(a) and Fig. 1(b), respectively.



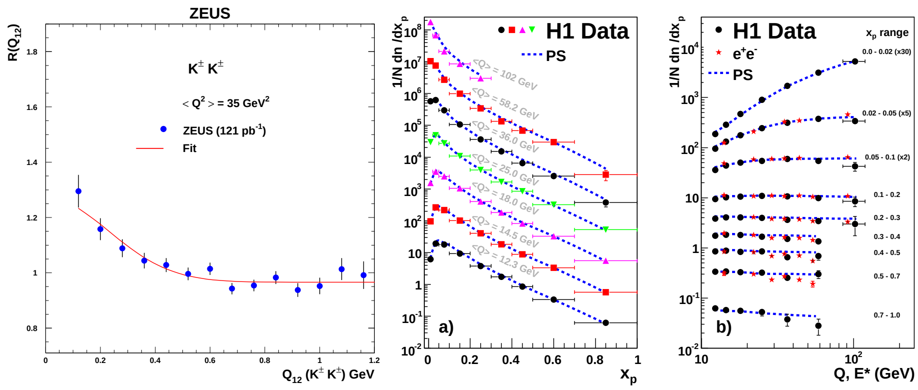
(a) (b)

Fig. 1. Differential K_S^0 cross-sections for (a) low and high Q^2 DIS and (b) γp.

The DIS cross-sections are compared to ARIADNE and LEPTO Monte Carlo (MC) calculations. ARIADNE with $\lambda_s = 0.3$ (strangeness suppression factor) describes the data reasonably well while the ARIADNE with $\lambda_s = 0.22$ and LEPTO MC predictions are less satisfactory. A similar comment can be made for the $\Lambda + \bar{\Lambda}$ cross-sections. In γp the PYTHIA predictions describe the shape of the data dependence on p_T^{LAB} and η^{LAB} well. The x_γ^{OBS} dependence at smallest x_γ^{OBS}, corresponding to the resolved-photon region, is not good. For baryon–antibaryon asymmetry measurements, no significant difference between Λ and $\bar{\Lambda}$ was found. This suggests that in the considered parts of the *ep* phase-space, baryons and antibaryons are produced according to the same mechanism. The ARIADNE MC predictions ($\lambda_s = 0.3$) for baryon to meson ratios for DIS samples follow the shape of the data. For the γp sample baryon to meson ratio in function of x_γ^{OBS} increases up to 0.7 at low x_γ^{OBS} corresponding to almost pure resolved γp region which is not expected by PYTHIA. It was also found that for the ratio of strange to light hadrons, a lower value of the strangeness suppression factor ($\lambda_s = 0.22$) is favoured over the default ($\lambda_s = 0.3$).

3. Bose–Einstein correlations of $K^0_{\rm S}K^0_{\rm S}$ and $K^{\pm}K^{\pm}$ in DIS

The study of the size of BEC of identical bosons pairs in DIS has been extended to pairs of $K^{\pm}K^{\pm}$ and $K^0_{\rm S}K^0_{\rm S}$. The two-particle correlation function $R(Q_{12})$ was calculated using the double ratio method and divided by correction coefficient to remove correlations other than BEC. The $R(Q_{12})$ formula is given as follows: $R(Q_{12}) = \frac{P(Q_{12})^{\rm data}}{P_{\rm mix}(Q_{12})^{\rm data}} / \frac{P(Q_{12})^{\rm MC,noBEC}}{P_{\rm mix}(Q_{12})^{\rm MC,noBEC}}$, where the so-called mixed-event sample $P_{\rm mix}$ contains pairs of bosons coming from different events. Q_{12} is given by $Q_{12} = \sqrt{-(p_1 - p_2)^2} = \sqrt{M^2 - 4m_{\rm boson}}$, where M is the invariant mass of the two particles with four-momenta p_1 and p_2 and mass $m_{\rm boson}$. Assuming a Gaussian shape of emission source, $R(Q_{12})$ can be described by the standard Goldhaber-like function: $R(Q_{12}) = \alpha(1 + \lambda e^{-Q_{12}^2 r^2})$, where the most interesting parameters are r, a geometrical radius of the boson emitting source and λ, a coherence strength factor. Fig. 2(a) shows the measured two-particle correlation functions of $K^{\pm}K^{\pm}$. The similar fit was applied to $K^0_{\rm S}K^0_{\rm S}$ data. The extracted values of the BEC parameters for $K^{\pm}K^{\pm}$ are $\lambda = 0.37 \pm 0.07({\rm stat})^{+0.09}_{-0.08}({\rm sys})$, $r = 0.57 \pm 0.09({\rm stat})^{+0.15}_{-0.08}({\rm sys})$ fm while for $K^0_{\rm S}K^0_{\rm S}$ are $\lambda = 1.16 \pm 0.29({\rm stat})^{+0.28}_{-0.08}({\rm sys})$, $r = 0.61 \pm 0.08({\rm stat})^{+0.07}_{-0.08}({\rm sys})$ fm and $\lambda = 0.70 \pm 0.19({\rm stat})^{+0.28+0.38}_{-0.08-0.52}({\rm sys})$, $r = 0.63 \pm 0.09({\rm stat})^{+0.07+0.09}_{-0.08-0.02}({\rm sys})$ fm with 4% correction of $f_0(980)$.



(a) (b)

Fig. 2. (a) Bose–Einstein correlation function of $K^{\pm}K^{\pm}$ pairs. (b) The measured normalised distribution of the scaled momentum compared with the PS Monte Carlo.

4. (Anti)dueteron and (anti)proton production in DIS

The production of $d(\bar{d})$ in region has been observed by ZEUS. According to the coalescence model, which was first proposed to explain the production of $d(\bar{d})$ in heavy-ion collisions, the production rate of d is determined by the overlap between the wave-function of a proton (p) and neutron (n) with the wave-function of a d. In this case, the d cross-section is the product of single-particle cross-section for protons and neutrons, with a coefficient of proportionality reflecting the volume of the fragmentation region emitting the particles. The same approach applies for $\bar{d}$ and $\bar{p}$. If the coalescence parameter is the same for particles and antiparticles, then the production ratio $d/\bar{d}$ is equal $(\bar{p}/p)^2$. The first measurements of $d/\bar{d}$ in ZEUS shows that the production rate $d/\bar{d}$ is smaller than that for $p/\bar{p}$ by three orders of magnitude, which is in broad agreement with other experiments. The coalescence parameter is in agreement with the measurements in photoproduction at HERA. The production rate of p is consistent with that of $\bar{p}$ in the kinematic range $0.3 < \frac{p_T}{M} < 0.7$. For the same kinematic region, the production rate of d is higher than that for $\bar{d}$.

5. Production of charged particles in DIS at HERA

The normalised scaled momentum distribution, $D(x_p, Q) = \frac{1}{N}\frac{dn}{dx_p}$, of charged hadrons and average charged multiplicity, $\langle n \rangle$, have been measured at high Q^2 in the Breit frame, where the photon virtuality Q, can be related to the momentum of the scattered parton. This allows a comparison to be made with the results of e^+e^- data and a with variety of models.

The results broadly support the concept of quark fragmentation universality in ep collisions and e^+e^- annihilation. The ZEUS results are in agreement with the H1 data for the charged multiplicity. For most of the Q range the H1 data are in good agreement with the parametrisation of the e^+e^- data. In case of normalised distribution of the scaled momentum, the H1 data were compared with MC that implements different models to describe the parton cascade and the hadronisation process. It was found, that both models tend to overestimate the multiplicity at higher Q. A summary of the results for the scaled momentum spectra is presented in Fig. 2(b).

The NLO QCD calculations for three different parametrisations of the fragmentation functions fail to describe the scaling violations seen in both H1 and ZEUS data.

REFERENCES

[1] S. Chekanov *et al.* [ZEUS Collaboration], *Eur. Phys. J.* **C51**, 1 (2007).

[2] S. Chekanov *et al.* [ZEUS Collaboration], *Phys. Lett.* **B652**, 1 (2007).

[3] S. Chekanov *et al.* [ZEUS Collaboration], *Nucl. Phys.* **B786**, 181 (2007).

[4] F.D. Aaron *et al.* [H1 Collaboration], *Phys. Lett.* **B654**, 148 (2007) `[arXiv:0706.2456 [hep-ex]]`.

[5] ZEUS Preliminary 07-006(214) can be found at: `http://www-zeus.desy.de/physics/qcd/pubplots/`